NEXT GENERATION INSECT LIGHT TRAPS: THE USE OF LED LIGHT TECHNOLOGY IN SAMPLING EMERGING AQUATIC MACROINVERTEBRATES

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Abstract

LED lights were trialled as a replacement for traditional fluorescent bulbs for catching emerging aquatic macroinvertebrates. Initial trials with white LEDs were disappointing, with the catch amounting to chance contact with the trap, but when ultraviolet LEDs were used, there was no significant difference from the traditional fluorescent trap of the same design. While the fluorescent trap used most or all of the available battery power, the LED lights used less than 10% of the available power. It is suggested that LEDs can be used to replace the more power-demanding traditional lights for use in light traps.

Introduction

Light traps have long been a popular choice for baseline surveys of winged invertebrates from mosquitos to moths and there have been many variations on light trap designs over the years. While their use in urban environments is facilitated by the availability of close power sources, field use has always been limited by the requirement of power to run traditional lights. Traditional fluorescent tubes often do not run for more than 12 hours from a traditional 12-volt power source such as a car battery.

Light traps have been used for insect trapping for over 100 years. In that time there have been many variations in design with some being extremely complex, involving both lights and fans (Venter *et al.* 2009), while others have remained simple (Scanlon and Petit 2008). The source of light has also varied, beginning with flames and moving on to incandescent bulbs and, in more recent times, fluorescent tubes. Most current traps employ either an incandescent bulb or actinic fluorescent tube as the light source, as the spectrum of light emitted from these bulbs is effective for attracting insects (Sambaraju and Phillips 2008). However, the power used by these light sources has always been an issue. Typically, small bulbs of around 6-9 watts are used which require either a fixed power source or a large power supply to power the light for an entire night. A common power source used is a 12-volt battery which will power such lights for approximately 6-8 hours, depending on the amp-hours of the battery. Given that the flight period of different insects varies from dusk until dawn, this means that standard light sources may fail to attract a portion of the available insect population (Williams 1935, Scalercio *et al.* 2009).

Over the last decade, light-emitting diodes (LEDs) have become increasingly popular as a replacement for standard incandescent bulbs or fluorescent bulbs as they are cheaper, run cooler, are more resistant to damage and use considerably less power. LEDs are also a much more focused light source with a narrow spectrum of light (generally 5 nanometres) and either a narrow beam (generally 25 degrees) or wide beam (Moreno and Sun 2008). This allows for specific lighting characteristics to be selected and tailored for a specific purpose. Previous work has indicated that the use of LEDs increased capture rates of sandflies by 50% (Cohnstaedt *et al.* 2008); however, the effectiveness of LEDs in attracting other types of insects has been little investigated. The purpose of this study was to examine whether LEDs could be used as a substitute for an actinic fluorescent bulb in a conventional light trap, and to examine the effect of this substitution on capture rates of emerging aquatic macroinvertebrates.

Methods

For this study three different lights were trialled. All light sources used were attached to a "heath" style trap that employs three transparent upright vanes radiating out from a central point and light source. The vanes sit over a vertical funnel leading into a chamber where the insects are trapped until collection. In order to keep the trap stable under windy conditions the vanes were anchored to a stake. All lights were attached to an 18 amp-hour 12-volt battery (5-in-1 Power station/Jump starter (MB-3594), PowerTech). The first light source trialled was a commercially available 8 watt actinic fluorescent bulb (E700, Australian Entomological Supplies Pty. Ltd, Australia). The second was two banks of four white LEDs (6500 nm, 3000 millicandela), and the third was two banks of nine 2000 millicandela 'UV/black light (395 nm)' LEDs (Fig. 1).

These traps were trialled in the Sturt River Gorge, South Australia, from 5-8 December 2011. Given the documented variation in catch due to weather conditions (Williams 1940, Yela and Holyoak 1997) and moonlight (Bowden and Church 1973, Yela and Holyoak 1997), these details were recorded. Two of the actinic fluorescent light type and two of the UV LED light trap were trialled over four consecutive nights. The traps were placed alongside pools separated by a minimum of 50 meters and at least one riffle section (Fig. 2). No other trap was visible from the trap location. The LED light traps were always directed towards the water, facing the steep side of the river valley. Traps were set at 8pm and collected at 7am.

Collected individuals were identified to Order using the CSIRO online invertebrate key (CSIRO 2011). In order to rule out any effect of sampling date on the results a one-way ANOVA was used. Differences between the samples collected by the different styles of trap were analysed using a series of independent samples t-tests for total number of individuals sampled per trap, total orders sampled per trap and the number of each order sampled per trap, treating the nightly catches as replicates. All statistical analysis was performed in IBM SPSS Statistics (Version 19).

Fig. 1. Constructed light trap showing banks of LEDs and general set-up of upright clear vanes positioned over a funnel.

Fig. 2. Sampling sites used for trialling the light traps in the Sturt River Gorge, South Australia. Site a: 35°2'58.49"S, 138°36'25.96"E. Site b: 35°2'57.18"S, 138°36'27.73"E. Site c: 35°2'58.49"S, 138°36'30.52"E. Site d: 35°3'0.69"S, 138°36'32.77"E.

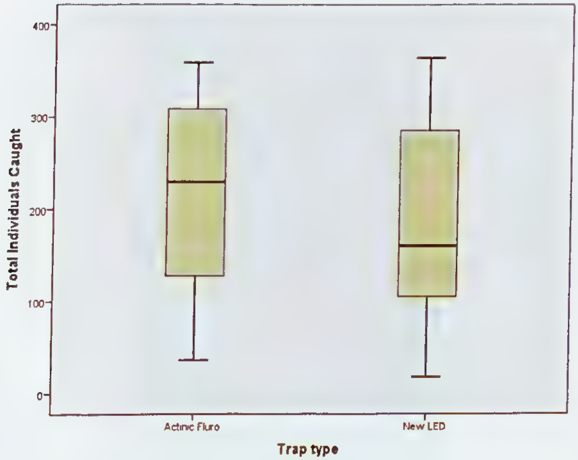

Fig. 3. Box plot of total individuals caught in the different styles of trap per night generated using IBM SPSS Statistics Version 19 (8 replicates). Bars represent minimum and maximum number of individuals caught per night, the middle bar represents the median.

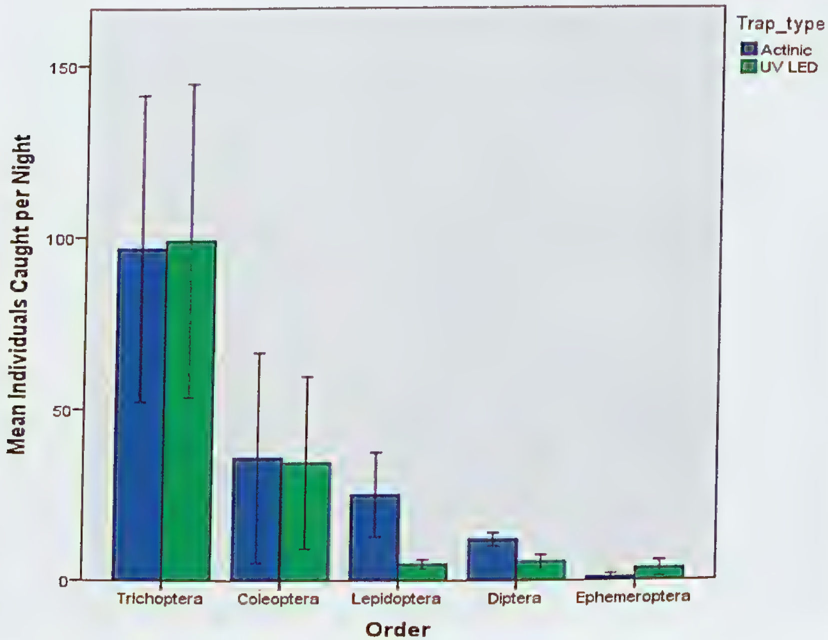

Fig. 4. Mean and error bar plot (+/- 1 standard error, 8 replicates) of the five most abundant orders caught in both UV LED and Actinic light traps (generated using IBM SPSS Statistics Version 19).

Results and discussion

The weather conditions varied little over the sampling period. There was light cloud cover ranging from 10-20% on each of the sampling nights. The moon phase was day 11 through 15. The wind direction and speed varied from night to night; however, due to the location of the trapping site, a well vegetated river gorge, the effect of wind was likely minimal. There was no significant effect of sampling date on the invertebrates caught shown by the one-way ANOVA conducted for the total number of individuals caught, as well as on each individual order (all results $p>0.05$).

The White LED light traps were relatively ineffective, with the insect catch apparently amounting to no more than incidental collision with the clear vanes (total 7 individuals) and were discarded after the first two nights. Therefore, we focused on comparing the UV LED traps and the actinic fluorescent trap. The results indicated that there was little difference between the catch from either trap type. The most commonly caught insects were Trichoptera, followed by Coleoptera (Fig. 4). When looking at the total insect abundance, there were on average slightly fewer individuals caught in the UV LED traps; however, this difference was not significant (Fig. 3, $t=0.490$, $df=13.982$, $p=0.631$). Independent samples t-tests were also done on individual orders to see if there was an order specific difference in the sample. There was a trend towards more Lepidoptera and Diptera in the actinic light traps; however, this was found to be not significant using an independent samples t-test for the four replicates ($p>0.05$). It is possible that these results are related to the 360 degree spread of light from the actinic bulb rather than the 120 degree spread of light from the UV LED traps. In addition, the light from the UV LEDs was directed largely over the water body, rather than towards the vegetation. Given that all orders trapped in this study appear to be attracted to both light sources, we hypothesise that, given a full 360 degree spread of light (achieved by adding more LEDs or modifying the arrangement of the LEDs), the results may have been more similar.

Power consumption was measured using the inbuilt voltmeter on the jump starter battery packs and analysed using an independent samples t-test. The power consumption significantly differed between the two trap types as expected ($t=32.16$, $df= 8.84$, $p<0.00$, $n=4$). While running off 18 amp-hour batteries the LED light traps used, on average, less than 10% of the available power while the actinic fluoro used, on average, 92.5% of the available power, with some trials using 100%. This may have led to discrepancies among catches as it was unclear when the battery power was exhausted for some of the fluorescent light traps.

Given the results of this study, we propose that UV LEDs may often be used in place of traditional light sources in insect light traps. LEDs can be easily retrofitted to any existing light trap and are inexpensive to buy. They are also more durable, longer lasting, more power efficient and easier to repair. The

LED light traps used in this study were constructed from commonly available materials for less than $60AUD each. LEDs also commonly run on 12 volts DC, which reduces the risk of electric shock to the operator as fluorescent tubes may require high voltages to start and inverters to run. This study found no significant differences in the abundance or composition of the insects caught by LED-based and fluorescent tube based light traps, even when the LEDs only illuminated 120 degrees while using less than an eighth of the power of the fluorescent lights. While we believe that UV LED light traps are a good replacement for actinic light traps, largely because of their lower power consumption and more robust design, we believe considerably more work is required to assess the relative attractiveness of LED and traditional light sources to specific insect orders.

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